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(54) SYNCHRONOUS ELECTRIC MOTORS

(71) We, N.V. ELECTROMOTORENFABRIEK 'DORDT', a Dutch Company, of Dordrecht, the Netherlands, do hereby declare the invention for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The invention relates to a synchronous electric motor of the inductor kind.

Certain synchronous electric motors of the inductor kind are known to possess the inherent advantages of eliminating the need for a rotating winding so that elements such as slip-rings, brushes, etc. are not required. Such motors tend, however, to have the disadvantage of magnetic leakage. An example of this kind of motor is described in the specification of United States Patent No. 2,073,760 of March 16, 1937.

According to the invention there is provided a synchronous electric motor having a casing; at least a pair of axially spaced annular core members fixed within the casing; field winding means fixed within the casing and disposed between the core members for establishing a closed d.c. magnetic field extending axially within the casing and passing radially through the core members; polyphase winding means extending through the core members and circumferentially of the casing for establishing a rotating field within the casing; a rotor journalled in the casing concentrically of the core members and the winding means, the rotor including a shaft and at least a pair of squirrel cage windings fixed to the shaft and including circumferentially spaced electrically connecting rods and end plates, each squirrel cage winding being radially aligned with a respective one of said core members; and magnetic cores each at least partly contained by a respective one of said squirrel cage windings and having radially projecting pole pieces pierced by some of said rods; in use said d.c. field magnetising said magnetic cores to establish a magnetic lock between said magnetic cores and the rotating polyphase field after said rotor has been started by asynchronous inductive interaction between said rotating field and said squirrel cage windings.

Mounting two or more of the squirrel cage winding-magnetic core assemblies on an enlarged magnetically conductive shaft portion and providing a spacer ring or rings of magnetic material between the assemblies permits a high magnetic flux density to be employed and tends to minimise magnetic leakage. The magnetic cores are preferably formed as laminations and comprise main body portions and radially projecting pole pieces, the spacer ring or rings preferably being of an outer diameter similar to the outer diameter of the main body portions of the laminations. End plates of the squirrel cage windings sandwich the laminations of the magnetic cores between them and the conducting rods joining the end plates are preferably evenly spaced with some extending through the pole pieces and others received in notches in the main body portions of the pole piece laminations. This results in a simple, rugged and economical construction. Shielding against magnetic leakage can be provided not only by the use of non-magnetic opposite end portions of the rotor shaft, but by the use of casing end shields and by spacer sleeves extending from the opposite ends of the enlarged magnetic portion of the shaft to these casing end shields.

The invention is diagrammatically illustrated by way of example in the accompanying drawings, in which:—

Figure 1 is a view, partly in section, of a four pole synchronous electric motor according to the invention;

Figure 2 shows a rotor of the motor of Figure 1;

Figure 3 is a part sectional view of another embodiment of a synchronous electric motor according to the invention;

Figure 4 shows a diagram of two mechanically coupled switches whereby a d.c. supply to a field winding can be switched on simultaneously with an a.c. supply, and

Figure 5 shows a diagram of a circuit where-

by a d.c. supply to a field winding can be connected with a delay after connection of the a.c. supply.

Referring to the drawings, the stator of an electric motor includes a substantially cylindrical housing 1 provided at opposite ends with end shields 2 and 3 which are connected to the housing 1 by means of bolts 4, 5 respectively. The end shields 2 and 3 are each provided with a central opening to receive a respective ball bearing 7 and 8 for rotatably supporting a rotor shaft 6 in the end shields 2, 3, the ball bearings 7, 8 having end covers 9 and 10 and suitable felt dust seals 11 and 12. That end of the shaft 6 to the left as viewed in Figure 1 is provided with a bladed fan 13 shielded by a cover 14, which is fastened to the housing 1 by means of bolts 15. The opposite end of the shaft is provided with a suitable keyway 16. A d.c. winding 17 serves to magnetise poles on the rotor. On both sides of a spacing ring member enclosing the winding 17, laminated core structures 18 and 19 are provided bearing a polyphase winding 20 by means of which a rotating field is produced.

The rotor shaft 6 includes opposite end portions which are of non-magnetic material and an enlarged intermediate portion 6′ which is of magnetic material. On the intermediate portion 6′ a pair of combined squirrel cage winding-magnetic core assemblies are mounted. One of the squirrel cage windings includes opposite end plates 30 and 32 joined by conducting bars 27 which are short-circuited by the end plates. The other squirrel cage winding comprises end plates 34 and 36 joined by conducting bars 27′. Sandwiched between each pair of end plates are laminations forming magnetic cores, each lamination having an annular main body portion provided with two or more radially projecting portions forming pole pieces. The radially projecting portions of one magnetic core present pole pieces 23 and 24 while the radially projecting portions of the other magnetic core present pole pieces 25 and 26. The pole pieces of the two assemblies are circumferentially staggered as can be seen from Figure 2.

The outer edges of the main body portions of the laminations of the magnetic cores between the pole pieces are notched to receive the inner edges of their respective conducting bars 27 and 27′ and the axial length of the magnetic cores are commensurate with the axial lengths of the core members 18 and 19 with which they are radially aligned. The end plates 30 and 32 thus lie in respective planes located beyond the end faces of the core member 18 while the end plates 34 and 36 lies in respective planes located beyond the end faces of the core member 19.

Each of the squirrel cage winding-magnetic core assemblies is of rugged yet simple and economical unitary constructino and may be suitably assembled onto the intermediate portion 6′ of the rotor shaft. Between these two assemblies in embracing relation to the shaft portion 6′ is a spacer ring 22 of magnetic material whose outer diameter is substantially the same as the outer diameter of the main body portion of the laminations of the magnetic cores and which is of an axial length properly to orient the assemblies as aforesaid. To complete the rotor, axial spacer sleeves 50 are provided between the opposite end faces of the intermediate portion 6′ of the rotor shaft, extending to the respective shields 2 and 3 and engaging the bearings thereby axially to position the rotor and to enhance the magnetic shielding effect.

The concentric exciting winding 17 is supplied with direct current and excites an axially directed d.c. field with a magnetic circuit passing through the housing, the shaft, the core structures of the stator and the magnetic cores. The polarity of the magnetic cores on the rotor depends on the direction of this field. When the motor is being started rotating fields excited by means of the winding 20 will, owing to the squirrel cage windings, impart an asynchronous rotational movement to the rotor, until the excitation of the field winding and the presence of the protruding pole pieces cause the rotor to rotate synchronously with the rotating field on the stator. It is an advantage of the motor that without exciting windings on the rotor being fed by means of slip rings, a controllable exciting field is provided.

Figure 3, wherein like reference numbers indicate like parts to those shown in Figure 1, illustrates a modification in the arrangement and position of the exciting windings. Two axially spaced field exciting windings 17, 17′ are provided with a common laminated core structure 28 between them. On the rotor three squirrel cage winding-magnetic core assemblies are provided and located opposite to the core structures on the stator. Between pairs of end plates 30, 32: 38, 40: and 34 and 36; electrically conductive rods 27; 27″; 27′ respectively extend. On the rotor three magnetic cores 24, 25 and 25′ are positioned. The magnetic core 25 has about twice the axial length of each of the magnetic cores 24, 25. In this way a motor with a relative large power is obtained. This modification can be employed if the outer diameter has to be limited.

The diagram of Figure 4 shows a circuit in which switches 41, 42, located respectively in an a.c. supply circuit and a d.c. supply circuit are mechanically coupled, so that the d.c. supply is switched on and the field winding is excited simultaneously with the polyphase winding. This arrangement will be employed if the d.c. field is of relative small strength.

Figure 5 shows a diagram of a circuit in

which by means of a delay time relay 43 a switch 44 will be actuated a certain time interval after the switch 45 has been actuated by actuating the start switch in the form of a push button 46. The motor can be switched off by breaking the circuit by means of a switch 47. This arrangement will be applied if a relative large d.c. field excitation is employed. With this arrangement the motor will start asynchronously by means of the squirrel cage windings and after the switch 44 is actuated the motor will rotate synchronously with the polyphase field. Employing squirrel cage windings also provided advantages with respect to the damping of the motor.

The motor according to the invention may be easily and cheaply produced since it does not require excitation windings, brushes and slip rings on the rotor.

WHAT WE CLAIM IS:—

1. A synchronous electric motor having a casing; at least a pair of axially spaced annular core members fixed within the casing; field winding means fixed within the casing and disposed between the core members for establishing a closed d.c. magnetic field extending axially within the casing and passing radially through the core members; polyphase winding means extending through the core members and circumferentially of the casing for establishing a rotating field within the casing; a rotor journalled in the casing concentrically of the core members and the winding means, the rotor including a shaft and at least a pair of squirrel cage windings fixed to the shaft and including circumferentially spaced electrically conducting rods and end plates, each squirrel cage winding being radially aligned with a respective one of said core members; and magnetic cores each at least partly contained by a respective one of said squirrel cage windings and having radially projecting pole pieces pierced by some of said rods; in use said d.c. field magnetising said magnetic cores to establish a magnetic lock between said magnetic cores and the rotating polyphase field after said rotor has been started by a synchronous inductive interaction between said rotating field and said squirrel cage windings.

2. A synchronous electric motor according to claim 1, in which there are two core members and two squirrel cage windings, a first of said squirrel cage windings having its end plates surrounding the shaft in axially spaced relation and lying in respective planes located beyond end faces of a first of said core members, a second of said squirrel cage windings having end plates surrounding the shaft in axially spaced relation and lying in respective planes located beyond end faces of a second of said core members, the rotor includes a spacer of material of good magnetic conductivity disposed between the adjacent end plates of said two squirrel cage windings, a first of the magnetic cores disposed between the end plates of said first squirrel cage windings has two pole pieces disposed adjacent said first of said core members and a second of the magnetic cores disposed between the end plates of said second squirrel cage winding has two pole pieces disposed adjacent said second of said core members, the pole pieces of the two magnetic cores being circumferentially staggered.

3. A synchronous electric motor according to claim 1, in which there are three core members, one of said core members being intermediate the other two of said core members and having an axial length substantially equal to the cumulative lengths of the other two of said core members, said field winding means comprises two field windings, a first of the field windings being disposed between said one of said core members and a first core member of said other two core members and a second of the field windings being disposed between said one of said core members and a second of said other two core members, and in which the rotor includes three squirrel cage windings each having its pair of end plates lying in respective planes located beyond end faces of a respective one of the three core members with which it is radially aligned.

4. A synchronous electric motor according to any one of claims 1 to 3, in which the casing includes opposite end shields, and the rotor includes a shaft having an enlarged intermediate portion of magnetic material and opposite end portions of non-magnetic material projecting through and journalled in said end shields.

5. A synchronous electric motor according to any one of claims 1 to 4, in which the magnetic cores comprise laminated main body portions with the pole pieces projecting radially therefrom and said main body portions are notched to receive radially inner side portions of said conducting bars.

6. A synchronous electric motor according to claim 4 or claim 5 when appendant to claim 4, including spacer sleeves extending from the opposite ends of said intermediate portion of the shaft to said end shields.

7. A synchronous electric motor substantially as hereinbefore described and illustrated with reference to Figures 1 and 2 or Figure 3 of the accompanying drawings.

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1286035 COMPLETE SPECIFICATION

2 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 1

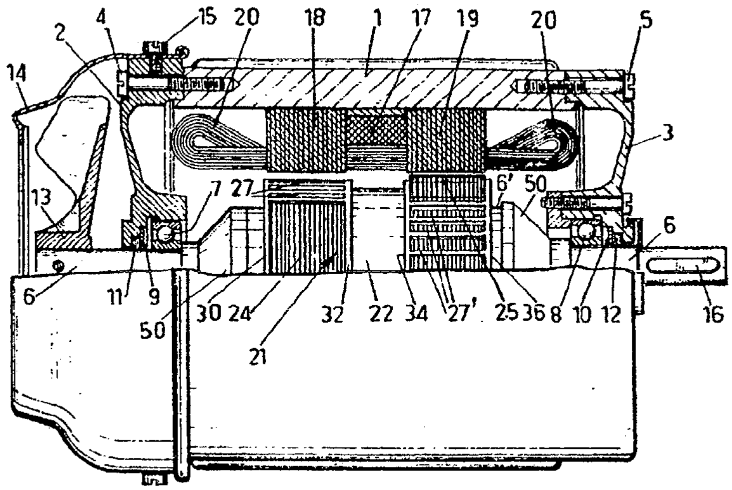

FIG.1

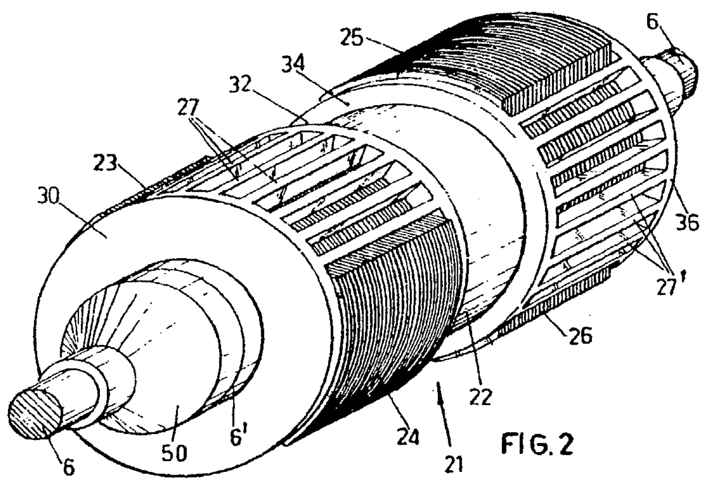

FIG.2

1286035 COMPLETE SPECIFICATION

2 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 2

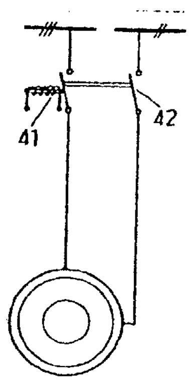

FIG. 4

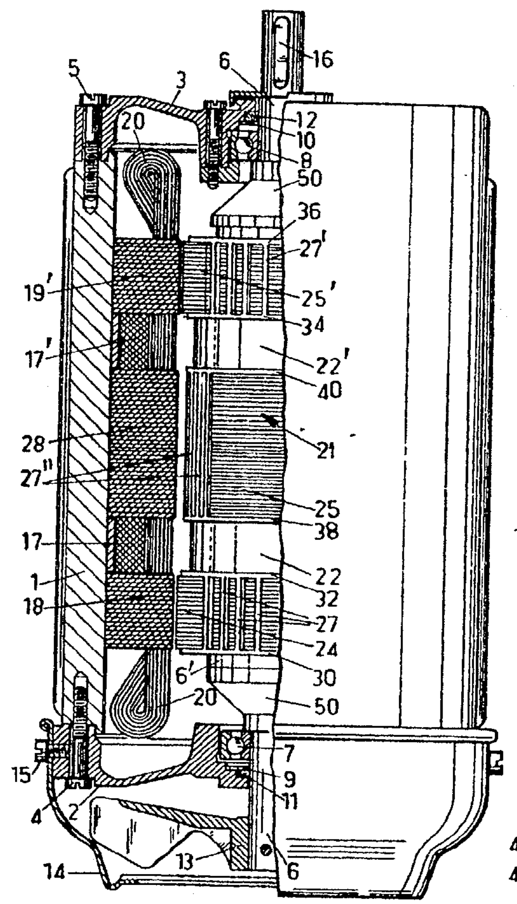

FIG. 3

FIG. 5